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METHANE EMISSION IN LONGWALL DISTRICTS WITH SPECIAL REFERENCE TO 14 NORTH DISTRICT OF NO. 26 COLLIERY

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April 1985

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METHANE EMISSION IN LONGWALL DISTRICTS WITH SPECIAL REFERENCE TO 14 NORTH DISTRICT OF NO. 26 COLLIERY

by

B.W. KONDA*

ABSTRACT

Although much work has been done in the last two decades, the science of predicting methane in longwall districts is still in its early stages of development. After a brief review of the elements related to methane emission in longwall districts, this report attempts to interpret the data obtained in a methane survey of the 14 North District of No. 26 Colliery in Sydney Coalfield, conducted by D. Kennedy and C. White of Labour Canada during late 1983 and early 1984 period.

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ÉMISSIONS DE MÉTHANE DANS LES DISTRICTS D'EXPLOITATION PAR LONGUES TAILLES EN PARTICULIER DANS LE DISTRICT 14 NORD DE LA MINE N° 26.

par

B.W. KONDA*

RÉSUMÉ

Bien que de nombreux travaux de recherche sur les émissions de méthane aient été effectués au cours des deux dernières décennies, l'art de prévoir les émissions de méthane dans les districts d'exploitation par longues tailles n'en est encore qu'à ses débuts. Le rapport présente un bref exposé sur les facteurs qui peuvent contribuer aux émissions de méthane dans les districts d'exploitation par longues tailles et une interprétation provisoire des données recueillies au cours d'une étude effectuée dans le district 14 nord de la mine n° 26 à la houillère de Sydney par D. Kennedy et C. White de Travail Canada dans la période allant de la fin de l'année 1983 au début de l'année 1984.

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INTRODUCTION

Although much work has been done in the last two decades to understand the methane release and flow from coal and surrounding strata into mine workings, the science of predicting methane emission in longwall districts is still in its infancy and most existing approaches are empirical in nature. Some rely on rock mechanics observations and others on local experiences of methane emissions and still others on speculations. However, in recent years some attempts have been made to make detailed in situ, as well as laboratory investigations, into mechanisms of methane release and flow into mine workings as well as some mathematical modelling. In this report, we will not attempt to review these techniques but will only make some observations on the elements related to methane emission in longwall districts and review the results of methane gas surveys of the 14 North District of No. 26 Colliery conducted during the period October 17, 1983 to January 31, 1984 by D. Kennedy and C. White of Labour Canada.

METHANE EMISSION IN LONGWALL DISTRICTS

The primary sources of methane entering longwall districts are: a) the coal seam being worked and b) the coal seams in relaxed roof and floor strata. Other carbonaceous or porous strata may sometimes contain significant quantities of methane and could contribute to the methane emissions in the district. The main elements that determine the quantity of gas released into the district are 1) the original gas content of the source, 2) the gas emitting zone (the influence zone or relaxed zone) and 3) the degree of gas emission from each source.

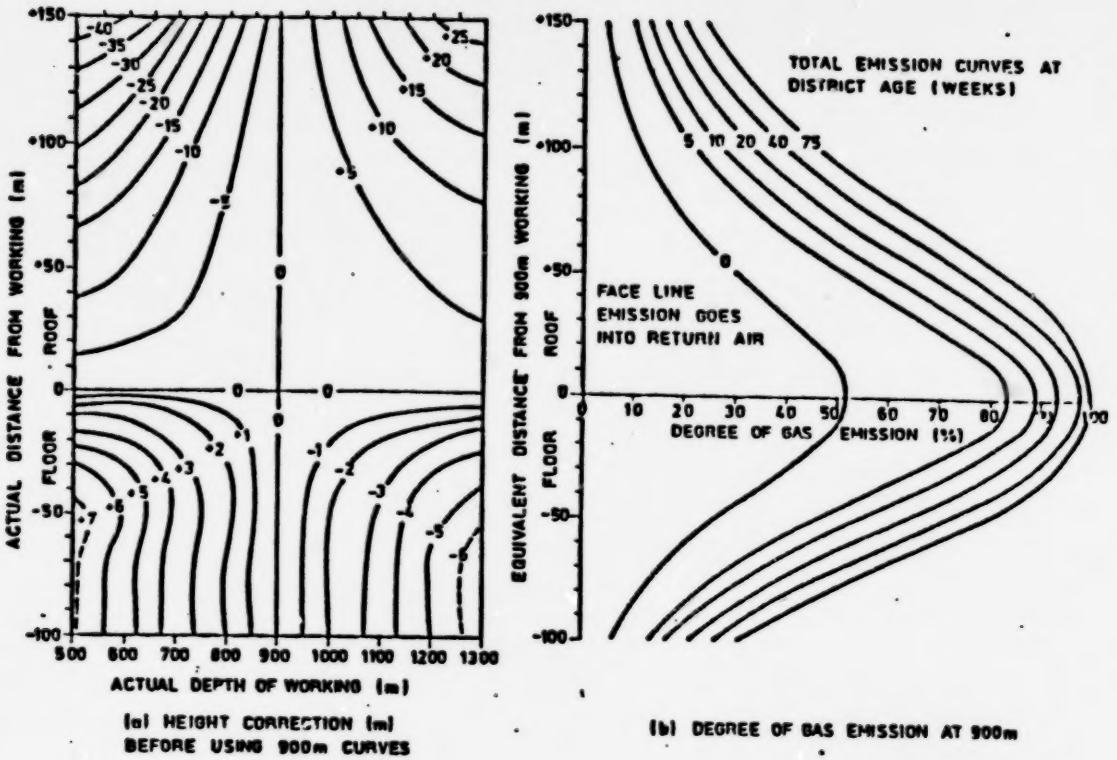
Methane from the worked seam can flow through the seam to the coalface or can migrate through adjacent strata to the relaxed zone behind the advancing face. However, some experimental studies in British coal mines with holes bored in the seam ahead of the face, appear to indicate high emission rates close to the face followed by a sharp drop after a depth of about 2 to 5 meters (1). This could be attributed to stress and permeability changes in the coal seam ahead of the advancing coalface. As the coal gives up its methane only so close to the face, it is likely that the gas will migrate to the coalface rather than into the surrounding strata. More gas will be released when the coal is cut and the amount will depend on the

degree of breakage. While the total methane emission from the worked seam increases with increased rate of face advance, the emission rate or the emission per ton of coal tends to decrease with increased rate of advance. This could be attributed to reduced desorption time for the coal ahead of the coalface. Some of the non-liberated gas still in the cut coal will desorb as it leaves the district and the amount of this gas will depend on the remaining gas content, the size distribution, the time it takes to transport coal out of the district and the desorption rate of the coal. This could amount to 12 - 20% of the remaining gas in the first 20 minutes (Figure 1).

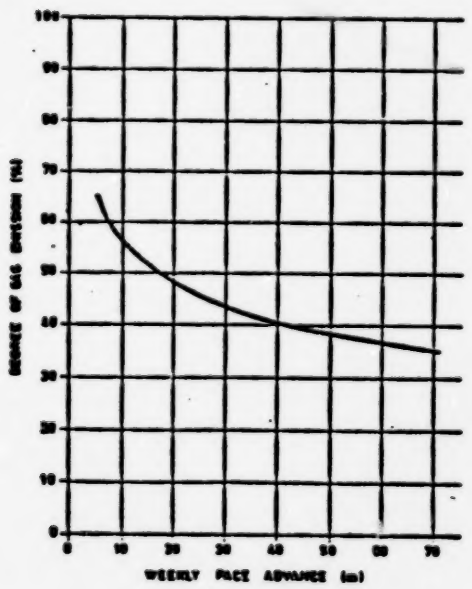
The mine openings disturb the strata and the resulting fractures create flow paths for the gas in the seam and strata above and below in the relaxed zone (Figure 2). In the virgin state gas in coal is at high pressure and the mine workings at near atmospheric pressure provide a pressure sink into which methane flows from the relaxed zone surrounding the openings. The proportion of the original gas content of the seams in adjacent strata that is released into main workings will depend on 1) the depth of mine workings, 2) the thickness of each individual seam in relation to the worked seam, 3) the distance of the seam above or below the working, 4) the length of the gateroad or the age of the district and 5) the method of mining. For the crack structure of the emission zone to have developed fully, the gateroad should be at least as long as the face. The National Coal Board's Mining Research and Development Establishment (MRDE) of U.K. developed curves for the degree of gas emission from seams in adjacent roof and floor strata based on Airey's work in rock mechanics (2) (Figure 1). More recently, scientists in West Germany carried out a large research project in which they measured gas pressures around longwall faces and calculated the gas emissions from adjacent seams and strata using the residual gas pressure curves (3). Methane drainage by cross-measure boreholes in the return gate captures a substantial portion of the gas released from seams in adjacent strata above certain distances.

METHANE SURVEY IN 14 NORTH DISTRICT OF NO. 26 COLLIERY

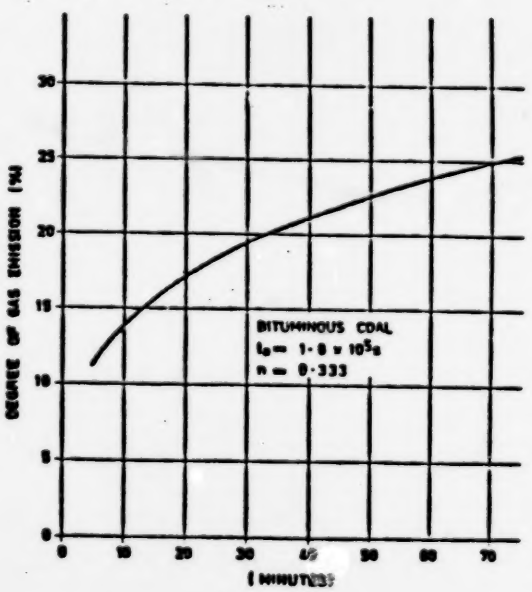
The Cape Breton Development Corporation's No. 26 Colliery is located in the town of Glace Bay, Nova Scotia. It was in operation for over 40 years and employed over 1200 people. It was closed in April 1984 due to a fire in the main intake Harbour seam roadways. The comments pertaining to


ACTUAL DISTANCE FROM WORKING (m)
ROOF
FLOOR
ACTUAL DEPTH OF WORKING (m)
(a) HEIGHT CORRECTION (m) BEFORE USING 900m CURVES
EQUIVALENT DISTANCE FROM 900m WORKING (m)
TOTAL EMISSION CURVES AT DISTRICT AGE (WEEKS)
FACE LINE EMISSION GOES INTO RETURN AIR
DEGREE OF GAS EMISSION (%)
(b) DEGREE OF GAS EMISSION AT 900m

Degree of Gas Emission Function for MRDE Prediction Method with Correction for Depth of Working

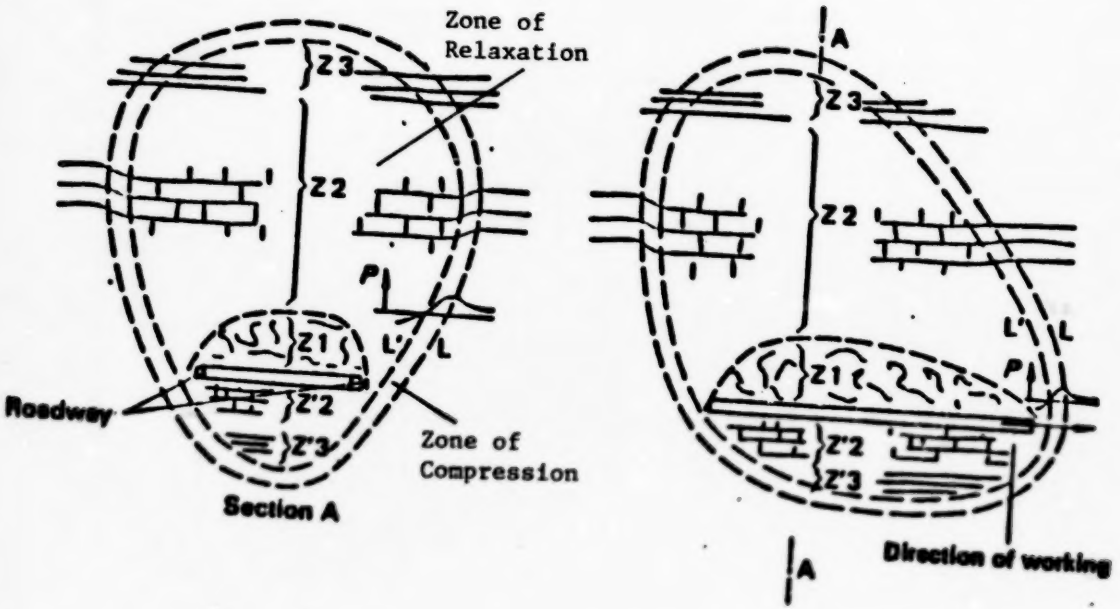


Degree of Gas Emission of Worked Seam



Degree of Gas Emission from Coal on a Conveyor

Figure 1 - Curves used in MRDE method of predicting methane emission in British coal mines



Z1: Caved Zone

Z2 & Z'2: Cracked Zone

Z3 & Z'3: De-stressed Zone

Figure 2 - Relaxed zones around a working

No. 26 Colliery in this report are related to the time of survey in late 1983 and early 1984.

The No. 26 was a "submarine colliery", that is, all its workings except those at the shaft itself were under the ocean. The workings were in the Harbour seam which is fourth in sequence of twelve seams identified in the Sydney Coalfield. The access to the workings was through the former 1B Colliery facilities. The Harbour seam is 2.2 m thick and the coal is high volatile 'A' bituminous with an average ash content of 3%, sulphur content of 0.9% and has an average calorific value of 34,400 KJ/kg.

The entrance to the mine was by means of two 205 m deep shafts, one of which was used entirely for men and air, the other was a double compartment shaft which hoisted 4 three ton cars at a time. The active workings were 7 km lateral distance from the shafts and +700 m below surface. The ventilation at the colliery was provided by means of a 1350 kw (1800 H.P.) Sirocco Centrifugal forcing fan supplying 12000 m^3/min at 487 mm of water gauge. The forced air system was supplemented by a 600 kw main booster fan exhausting air at 970 m^3/min and 176 mm water gauge, and two 225 kw sectional booster fans (Figure 3).

The 14 North longwall panel was started in June 1982 and operated until closing of the mine due to fire in April 1984. The wallface was 214 m long and a seam section of about 1.97 m was mined. The face was equipped with powered supports, ranging drum shearer and armoured face conveyor.

To study patterns of methane emission in 14 North District, a program of survey was initiated by Labour Canada. The program started on Monday, October 17, 1983 and concluded on Monday, January 30, 1984. During this period readings were taken on Mondays and Fridays and between 9:00 am and 1:00 pm for a total of 22 days (Table 1). For the survey purposes, the district was divided into 1) top material level or return gate, 2) wallface and 3) bottom coal level or intake gate. The survey commenced at the fire seal at the outbye end of the material level, proceeded inbye to the wallface and then into the intake gate, concluding at the BM1 monitor at the outbye end of the intake gate. For methane concentration measurements a National Mine Service (Model CD210) or a MSA (Model D-6) hand held digital read out methanometer was used and for air velocity measurements a J-Tech (VP-1000) or a vane type anemometer was used.

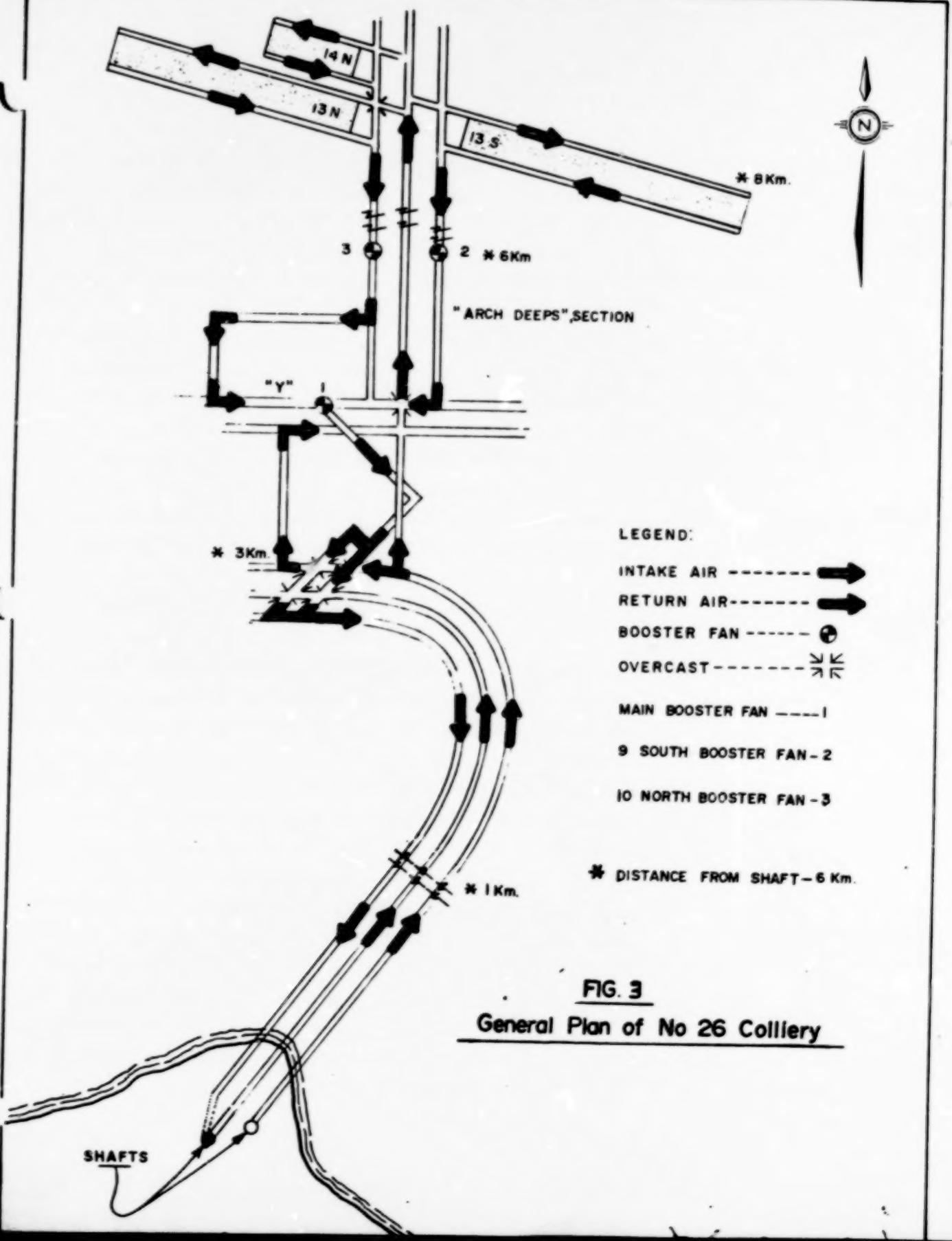


FIG. 3

General Plan of No 26 Colliery

Measurements in the Return Gate

1. Starting at the start of the longwall panel development, cross-sectional methane concentrations were measured every 100 arches to the wallface. Also methane concentrations in the gob were measured by inserting a probe through the pack.
2. Air velocities were measured at a) approximately 30 m inbye the fire seal located at the outbye end of the return gate and b) approximately 20 m from the wallface.
3. The following observations were checked and recorded:
   - reading of BM1 methanometer located at the outbye end of the return gate.
   - methane drainage W.G. and purity.
   - position of the last methane drainage borehole.

Measurements on the Wallface

1. Reading of BM1 methanometer located at the return end of the wall-face was checked against the hand held methanometer and the reading recorded.
2. Methane concentrations on the wallface were measured:
   a) on days when shearer was cutting, readings were taken every 10 jacks (approx. 15 m) at about 15 to 30 m on the return side of the shearer.
   b) on days when shearer was not cutting, readings were taken at approximately every 30 m.

Measurements in the Main or Intake Gate

1. Methane concentrations were measured a) in the alleyway b) at the stageloader and c) in the coal level at 15 m intervals to about 60 m from brushing.
2. Reading of BM1 methanometer located at the outbye end of the coal level was checked and recorded.
3. Air velocity measurements were made at approximately 20 m from brushing and at 30 m inbye of the fire seal.

SURVEY RESULTS AND CALCULATIONS:

Table 1 summarizes the methane measurements (A,B,C, & D), air measurements (E,F,G, & H) and calculated methane flows (I,J,K, & L) at various locations in the district. It also gives the methane drainage observations (M,N) and the calculated methane flow (O) in the drainage. Total methane flow in the district (P), barometric pressure (Q) and coal production (R) in the shift when measurements were taken are given in the next three columns. Methane flows adjusted for barometric pressure (S) and total methane flow per tonne of coal produced (T) are given in the next two columns.

Table 2 gives the calculated methane make in the intake (U), the wallface (V), the return (W) and that captured in the methane drainage (X). The total methane make in the district (Z) is then adjusted for barometric pressure (Q) to standard pressure (101.3 KPa). The adjusted methane make in the district (Z_1) is less than the adjusted methane flow (S) in the district and the difference ($S - Z_1$) is due to the methane content of the intake air (L) entering the district. This could be from development works outside the district or from the coal surfaces exposed to intake air in its long travel. Methane make per tonne of coal produced (Z_2) is calculated using coal production (R) in an eight hour shift ($Z_2 = \frac{Z \times 60 \times 60 \times 8}{R}$). The proportion of methane make in the intake (AE), on the wallface (BE), in the return (CE) and that captured in the methane drainage (DE) is then calculated.

As there is no specific information available regarding the sources (coal seam being mined and the seams in the relaxed strata above and below) and their original methane contents, it is not possible to quantify the emission rate from each source. However, by making certain assumptions regarding the way in which gas from various sources enters the airways or gas drainage boreholes, it is possible to estimate the approximate contribution each source makes to the total methane make in the district. Assumptions, of course, always represent an over simplication of what actually happens and therefore the estimates made should be taken in that light. The assumptions made are:

1. Methane make in the intake gate is solely from the conveyed coal.
2. Methane make on the wall face is from the coal ahead of the coalface of the seam being worked and the cut coal.

Table 1 - Methane survey in 14 North of No. 26 Colliery - measurements and calculations

NO.	DATE*	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
00001	17-10-83(M)	0.900	0.800	0.300	0.100	28.300	16.50	16.50	25.90	0.234	0.132	0.049	0.025	50.200	0.520	0.261	0.515	103.100	425	0.519	35.169
00002	21-10-83(F)	1.650	0.950	0.700	0.100	27.400	16.50	16.50	30.50	0.452	0.156	0.115	0.030	53.700	0.570	0.306	0.758	102.900	511	0.761	70.072
00003	24-10-83(M)	0.900	0.600	0.600	0.100	25.000	16.50	16.50	23.40	0.228	0.099	0.099	0.023	53.900	0.550	0.296	0.524	101.900	389	0.525	48.745
00004	28-10-83(F)	1.380	0.920	0.700	0.120	26.600	16.50	16.50	23.50	0.367	0.151	0.115	0.028	53.300	0.530	0.282	0.649	100.000	298	0.634	61.465
00005	31-10-83(M)	1.120	0.600	0.500	0.100	26.700	16.50	16.50	23.50	0.299	0.099	0.082	0.023	53.300	0.530	0.282	0.581	102.600	498	0.587	55.944
00006	04-11-83(F)	1.700	1.000	0.500	0.070	26.900	16.50	16.50	23.30	0.457	0.165	0.082	0.016	52.500	0.520	0.273	0.739	101.600	459	0.752	45.929
00007	07-11-83(M)	1.090	0.620	0.400	0.050	26.500	16.50	16.50	23.40	0.286	0.102	0.066	0.011	50.500	0.500	0.252	0.538	99.500	386	0.520	38.797
00008	14-11-83(M)	0.850	0.600	0.400	0.150	26.600	16.50	16.50	26.70	0.226	0.099	0.066	0.040	49.200	0.550	0.270	0.496	102.000	342	0.493	41.515
00009	18-11-83(F)	1.590	0.910	0.600	0.180	26.900	16.50	16.50	26.50	0.427	0.150	0.099	0.047	49.200	0.550	0.270	0.697	99.700	312	0.679	62.676
00010	21-11-83(M)	0.980	0.540	0.400	0.130	27.600	16.50	16.50	30.20	0.270	0.089	0.066	0.039	51.300	0.550	0.282	0.552	101.600	334	0.551	47.521
00011	25-11-83(F)	1.700	1.200	0.700	0.150	27.900	16.50	16.50	25.50	0.474	0.198	0.115	0.038	58.400	0.620	0.362	0.836	99.800	443	0.817	53.114
00012	28-11-83(M)	0.950	0.650	0.600	0.100	25.000	16.50	16.50	25.50	0.257	0.107	0.099	0.025	55.400	0.600	0.332	0.569	101.000	379	0.558	42.402
00013	02-12-83(F)	1.710	1.100	0.600	0.120	26.900	16.50	16.50	23.10	0.459	0.181	0.099	0.027	52.300	0.570	0.298	0.757	101.000	316	0.756	60.354
00014	05-12-83(M)	1.000	0.610	0.400	0.110	26.900	16.50	16.50	23.10	0.269	0.100	0.066	0.025	56.000	0.570	0.319	0.588	101.900	344	0.585	48.809
00015	09-12-83(F)	1.500	0.800	0.600	0.100	26.900	16.50	16.50	25.90	0.390	0.132	0.099	0.025	59.000	0.570	0.340	0.730	101.300	330	0.738	63.709
00016	16-12-83(M)	1.680	0.860	0.700	0.200	29.300	16.50	16.50	25.90	0.492	0.141	0.115	0.051	48.500	0.520	0.251	0.743	100.900	318	0.727	66.747
00017	30-01-84(F)	1.250	0.900	0.500	0.170	29.400	16.50	16.50	25.40	0.367	0.148	0.082	0.043	45.100	0.500	0.261	0.626	101.500	325	0.620	54.311
00018	09-01-84(M)	0.770	0.900	0.600	0.220	28.000	16.50	16.50	27.90	0.215	0.148	0.099	0.064	45.100	0.500	0.261	0.476	100.500	487	0.466	19.535
00019	13-01-84(F)	1.650	0.920	0.600	0.230	29.100	16.50	16.50	27.00	0.480	0.151	0.066	0.062	48.300	0.520	0.251	0.731	104.500	492	0.753	44.078
00020	23-01-84(M)	0.770	0.550	0.400	0.180	28.200	16.50	16.50	24.10	0.217	0.090	0.066	0.043	55.400	0.540	0.299	0.516	103.500	498	0.529	30.072
00021	27-01-84(F)	1.450	0.920	0.600	0.180	30.000	16.50	16.50	24.50	0.435	0.151	0.066	0.044	55.400	0.540	0.299	0.724	101.500	445	0.731	47.209
00022	30-01-84(M)	0.680	0.900	0.400	0.120	30.000	16.50	16.50	26.60	0.294	0.148	0.066	0.031	59.100	0.560	0.330	0.524	100.000	458	0.527	23.046

* M - Mondays; F - Fridays

A - reading of BM1 methanometer at the outbye end of the return (%CH_4)

B - reading of BM1 methanometer at the return end of the wallface (%CH_4)

C - reading of D-6 methanometer at the intake end of the wallface (%CH_4)

D - reading of BM1 methanometer at the outbye end of the intake (%CH_4)

E - volume of air flowing at the outbye end of the return (m^3/s)

F - volume of air flowing at the return end of the wallface (m^3/s)

G - volume of air flowing at the intake end of the wallface (m^3/s)

H - volume of air flowing at the outbye end of the intake (m^3/s)

I = $\frac{A \times E}{100}$ - volume of methane flowing at the outbye end of the return (m^3/s)

J = $\frac{B \times F}{100}$ - volume of methane flowing at the return end of the wallface (m^3/s)

K = $\frac{C \times G}{100}$ - volume of methane flowing at the intake end of the wallface (m^3/s)

L = $\frac{D \times H}{100}$ - volume of methane flowing at the outbye end of the intake (m^3/s)

M - Purity of gas flowing in the methane drainage pipeline for the district (%CH_4)

N - Volume of gas flowing in the methane drainage pipeline for the district (m^3/s)

$O = \frac{M \times N}{100}$ - volume of methane flowing in the methane drainage pipeline for the district (m^3/s)

$P = I + O$ - volume of methane flowing at the outbye end of the return + the volume flowing in the methane drainage pipeline for the district (m^3/s)

Q - Barometric pressure (KPa)

R - Coal production (tonnes/shift)

$S = \frac{P \times Q}{101.3}$ - total volume of methane adjusted for barometric pressure (m^3/s)

$T = \frac{S \times 28,800}{R}$ - total volume of methane per tonne of coal produced (m^3/tonne)

Table 2 - 14 North of No. 26 Colliery - methane makes and their proportions in various parts of the district

DATE	U	V	W	X	Z	Q	R	Z_1	Z_2	AE	BE	CE	DE	Z_3	Z_4
17-10-83(M)	0.0240	0.0830	0.1220	0.2610	0.4900	103.1000	425.0000	0.4790	32.2040	4.8970	16.9380	24.8970	53.2650	21.8350	78.1620
21-10-83(F)	0.0850	0.0410	0.2960	0.3060	0.7280	102.9000	311.0000	0.7390	67.4160	11.6730	5.6310	40.6390	42.0320	17.3060	82.6910
24-10-83(M)	0.0760	0.0000	0.1290	0.2960	0.5010	101.9000	309.0000	0.5030	46.4950	15.1690	0.0000	25.7480	59.0810	15.1690	84.8290
28-10-83(F)	0.0870	0.0360	0.2160	0.2820	0.6210	100.8000	295.0000	0.6170	60.0160	14.0090	5.7970	34.7820	45.4100	19.8060	80.1920
31-10-83(M)	0.0590	0.0170	0.2000	0.2820	0.5580	102.6000	498.0000	0.5650	32.2690	10.5730	3.0460	35.8420	50.5370	13.6190	86.3790
04-11-83(F)	0.0660	0.0830	0.2920	0.2730	0.7140	101.6000	459.0000	0.7160	44.8000	9.2430	11.6200	40.0960	38.2350	20.8670	79.1310
07-11-83(M)	0.0350	0.0360	0.1090	0.2520	0.5270	99.5000	386.0000	0.5170	39.3280	10.4360	6.8310	34.9140	47.8170	17.2670	82.7310
14-11-83(M)	0.0260	0.0330	0.1270	0.2700	0.4560	102.0000	342.0000	0.4590	38.0000	5.7010	7.2360	27.8580	59.2100	12.9370	87.0600
18-11-83(F)	0.0520	0.0510	0.2770	0.2700	0.6500	99.7000	312.0000	0.6390	60.0000	8.0000	7.8460	42.6150	41.5380	15.8460	84.1530
21-11-83(M)	0.0270	0.0230	0.1810	0.2820	0.5130	101.6000	334.0000	0.5140	44.2340	5.2630	4.4830	35.2820	54.9700	9.7460	90.2520
25-11-83(F)	0.0770	0.0830	0.2760	0.3620	0.7980	99.8000	443.0000	0.7860	51.6790	9.6490	10.4010	34.5860	45.3630	20.0500	79.9490
28-11-83(M)	0.0740	0.0090	0.1300	0.2220	0.5440	101.0000	379.0000	0.5420	41.2380	13.6020	1.4706	23.8970	61.0290	15.0726	84.9260
02-12-83(F)	0.0720	0.0820	0.2780	0.2980	0.7300	101.4000	316.0000	0.7300	66.5310	9.8630	11.2320	38.0820	40.8210	21.0950	78.9030
05-12-83(M)	0.0410	0.0340	0.1690	0.3190	0.5630	101.9000	344.0000	0.5660	47.1340	7.2820	6.0390	30.0170	56.6600	13.3210	86.6770
09-12-83(F)	0.0740	0.0330	0.2580	0.3400	0.7050	101.3000	330.0000	0.7050	61.5270	10.4960	4.6800	36.5950	48.2260	15.1760	84.8210
16-12-83(M)	0.0640	0.0260	0.3510	0.2510	0.6920	100.9000	310.0000	0.6890	62.6710	9.2480	3.7570	50.7220	36.2710	13.0050	86.9950
06-01-84(F)	0.0390	0.0660	0.2190	0.2610	0.5850	101.3000	525.0000	0.5850	32.0910	6.6660	11.2820	37.4350	44.6150	17.9480	82.0500
09-01-84(M)	0.0350	0.0490	0.0670	0.2610	0.4120	100.5000	427.0000	0.4080	17.2710	8.4950	11.9950	16.2620	63.3490	20.3880	79.6110
13-01-84(F)	0.0040	0.0850	0.3290	0.2510	0.6690	104.5000	492.0000	0.6900	39.1600	0.5979	12.7050	09.1770	37.5180	13.3020	86.6950
23-01-84(M)	0.0230	0.0240	0.1270	0.2990	0.4730	102.3000	498.0000	0.4820	27.3540	4.8620	5.0730	26.8990	63.2130	9.9350	90.0620
27-01-84(F)	0.0220	0.0850	0.2840	0.2990	0.6900	101.5000	445.0000	0.6910	44.6360	3.1880	12.3180	41.1390	43.3330	15.3060	84.4920
30-01-84(M)	0.0350	0.0820	0.0560	0.3380	0.5030	100.8000	458.0000	0.5000	22.0130	6.9580	16.3020	11.1330	65.4660	23.2600	76.7390
MEAN	0.0500	0.0482	0.2076	0.2899	0.5945	101.5409	414.0455	0.5973	44.5446	8.4487	8.0265	33.6090	49.9136	16.4753	83.5226
STD. DEV	0.0241	0.0281	0.0849	0.0314	0.1077	1.2215	111.3538	0.1073	14.2385	2.3849	4.3892	9.6643	9.2352	3.8145	3.8142
MINIMUM	0.0040	0.0000	0.0560	0.2510	0.4120	99.5000	295.0000	0.4080	17.2710	0.5979	0.0000	11.1330	36.2710	9.7460	76.7390
MAXIMUM	0.0870	0.0850	0.3510	0.3620	0.7980	104.5000	667.0000	0.7860	67.4160	15.1690	16.9380	50.7220	65.4660	23.2600	90.2520

U = K - L - methane make in the intake (m^3/s)

V = J - K - methane make on the wallface (m^3/s)

W = I - J - methane make in the return (m^3/s)

X = O - methane captured in the drainage system (m^3/s)

Z = (U + V + W + X) - total methane make in the district (m^3/s)

Q - barometric pressure (KPa)

R - coal production (tonnes/shift)

$Z_1 = \frac{Z \times Q}{101.3}$ = total methane adjusted for barometric pressure

$Z_2 = \frac{Z_1 \times 28,800}{R}$ = total methane make/tonne of coal produced

$AE = \frac{U}{Z} \times 100$ = % of methane make in the intake

$BE = \frac{V}{Z} \times 100$ - % of methane make on the wallface

$CE = \frac{W}{Z} \times 100$ - % of methane make in the return

$DE = \frac{X}{Z} \times 100$ - % of methane captured in the methane drainage

AE + BE + CE + DE = 100

Z_3 = AE + BE - methane make from the seam being mined

Z_4 = CE + DE - methane make from seams in adjacent strata

3. Methane from adjacent seams in the relaxed roof and floor strata both ahead and behind the face enters either the methane drainage or the return airway without polluting the face airstream.

Tracer gas experiments designed to determine the methane migration paths will be necessary to verify and seek inprovements to these assumptions. Based on the above assumptions, the contributions made by the seam being mined (Z_3) and that by the seams in the adjacent relaxed strata above and below (Z_4) are calculated.

The data in Table 2 is segregated into Monday's data (Table 3) and Friday's data (Table 4) to identify changes.

The methane concentrations in the general air body of the return gate and about 2 m into the gob (samples were taken by inserting a probe through the gateside pack at about 1 - 1.5 m above floor level) are given in Table 5 and plots of these readings in Figures 4a and 4b.

DISCUSSION OF RESULTS

Although various averages are calculated for the survey period, it must be understood that because of the nature of the survey (readings taken for only two shifts per week, one on Mondays and another one on Fridays) they do not represent any meaningful averages but only relative values. Averages for Mondays and Fridays can perhaps be considered as approximate representative values for those days. Assuming methane averages for Fridays are close to the peak values in the week, they can be used to evaluate the adequacy and the requirements of ventilation in the district. More importantly the data is used to study relative values and patterns of methane makes in various parts of the district.

The pattern of methane concentrations conforms to what is generally expected for such a district. Intake air entering the main or coal transportation gate on its way to the wallface picks up methane released by the coal being transported out of the district. Methane picked up in this section of the district is less than 10% of the total methane make in the district (Table 2). Methane released from the coal ahead of the coalface and the coal being cut is picked up by the air on its travel across the wallface and this again appears to be well below 10% of the total methane make in the district. It is generally very difficult to make accurate air measurements at both ends

Table 3 - 14 North of No. 26 Colliery - methane mades and their proportions, Mondays

DATE	U	V	W	X	Z	Q	R	Z_1	Z_2	AE	BE	CE	DE	Z_3	Z_4
17-10-83(M)	0.0240	0.0830	0.1220	0.2610	0.4900	103.1000	425.0000	0.4980	22.2040	4.5970	16.9380	24.8970	52.2650	21.8250	78.1620
24-10-83(M)	0.0760	0.0900	0.1290	0.2960	0.5010	101.9000	309.0000	0.5030	46.6950	15.1690	0.0000	25.7480	59.0610	15.1690	84.8290
31-10-83(M)	0.0590	0.0170	0.2000	0.2820	0.5580	102.6000	496.0000	0.5650	32.2690	10.5730	2.0460	32.8420	50.5370	13.6190	86.3790
07-11-83(M)	0.0250	0.0360	0.1840	0.2520	0.5270	95.5000	386.0000	0.5170	39.3200	10.4360	6.8310	34.9140	47.8170	17.2670	82.7310
14-11-83(M)	0.0260	0.0330	0.1270	0.2700	0.4566	102.6000	342.0000	0.4590	38.4000	5.7010	7.2360	27.8500	59.2180	12.9370	87.0600
21-11-83(M)	0.0270	0.0230	0.1810	0.2820	0.5130	101.6000	334.0000	0.5140	44.2340	5.2630	4.4830	32.2820	54.9700	9.7460	90.2520
28-11-83(M)	0.0740	0.0080	0.1300	0.3320	0.5440	101.0000	379.0000	0.5420	41.3380	13.6020	1.4700	23.8970	61.0290	15.0720	84.9260
05-12-83(M)	0.0410	0.0340	0.1690	0.3190	0.5630	101.9000	344.0000	0.5660	47.1340	7.2820	6.0390	30.0170	56.6600	13.3210	86.6770
16-12-83(M)	0.0640	0.0260	0.3510	0.2510	0.6920	100.9000	315.0000	0.6890	42.6710	9.2480	2.7570	35.7220	36.2710	13.9050	86.9930
04-01-84(M)	0.0350	0.0490	0.0670	0.2610	0.4120	103.5000	627.0000	0.4080	17.2710	8.4950	11.8930	16.2620	45.3490	20.3080	79.6110
23-01-84(M)	0.0230	0.0240	0.1270	0.2990	0.4730	103.3000	496.0000	0.4820	27.3540	4.8620	5.0730	26.8490	43.2130	9.9350	90.0620
30-01-84(M)	0.0250	0.0820	0.0560	0.3300	0.5030	100.8000	456.0000	0.5000	22.0150	6.9580	16.3020	11.1330	45.6060	23.2600	76.7390
MEAN	0.0449	0.0346	0.1536	0.2862	0.5192	101.5917	431.5000	0.5203	37.6588	8.5405	6.9223	28.6178	55.9173	15.4628	84.5351
STD. DEV	0.0197	0.0256	0.0761	0.0291	0.0695	1.1112	129.1078	0.0686	12.3310	3.4043	5.4435	16.1501	6.1927	4.3963	4.3980
MINIMUM	0.0230	0.0000	0.0560	0.2510	0.4120	99.5000	309.0000	0.4080	17.2710	4.8620	0.0000	11.1330	36.2710	9.7460	76.7390
MAXIMUM	0.0760	0.0830	0.3510	0.3320	0.6920	103.3000	687.0000	0.6890	62.6710	15.1690	16.9380	56.7220	65.6060	23.2600	90.2520

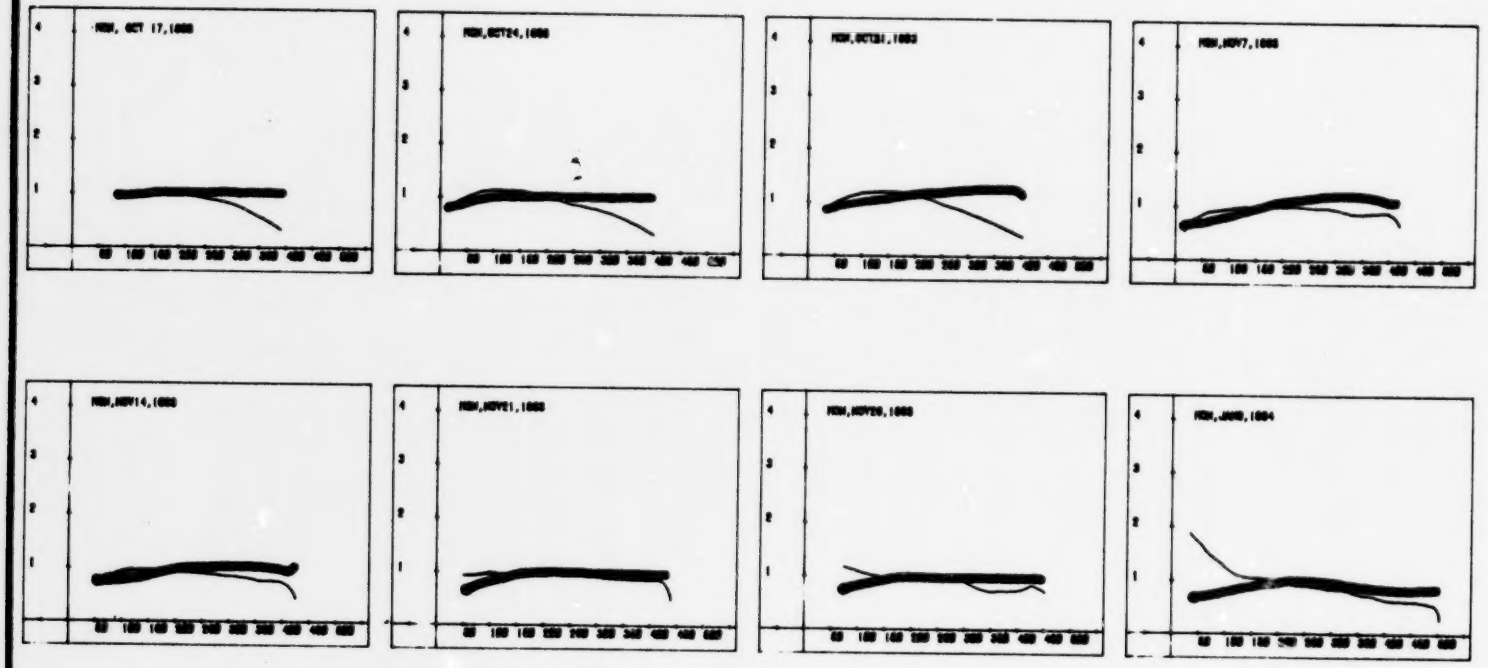
Table - 14 North of No. 26 Colliery - methane makes and their proportions, Fridays

DATE	U	V	W	X	Z	Q	R	Z_1	Z_2	AE	BE	CE	DE	Z_3	Z_4
21-10-83(F)	0.0550	0.0410	0.2960	0.3060	0.7280	102.9000	311.0000	0.7390	67.4160	11.6730	5.6310	40.6590	42.0220	17.3060	82.6910
28-10-83(F)	0.0870	0.0360	0.2160	0.2820	0.6210	100.8000	298.0000	0.6170	60.0160	14.0090	5.7970	34.7820	45.4100	19.8060	80.1920
04-11-83(F)	0.0660	0.0830	0.2920	0.2730	0.7140	101.6000	459.0000	0.7160	44.8060	9.2430	11.6290	46.8960	38.2350	20.8670	79.1310
18-11-83(F)	0.0520	0.0510	0.2770	0.2700	0.6500	99.7000	311.0000	0.6390	60.0000	8.0000	7.8460	42.4130	41.5380	15.8460	84.1530
25-11-83(F)	0.0770	0.0830	0.2760	0.3620	0.7980	95.8000	443.0000	0.7860	5..870	5.6490	12.4010	24.3860	45.3630	20.0200	79.9490
02-12-83(F)	0.0720	0.0820	0.2780	0.2980	0.7300	101.4000	316.0000	0.7300	62.5310	9.8630	11.2220	32.0820	4..8210	21.0950	78.9030
09-12-83(F)	0.0740	0.0330	0.2580	0.3400	0.7250	101.3000	330.0000	0.7250	61.8270	10.4960	4.6800	36.5950	48.2260	15.1760	84.8210
06-01-84(F)	0.0390	60	0.2190	..2610	0.585.	101.3000	522.0000	..585.	32.0910	6.0660	11.2220	37.4230	44.6150	17.9480	82.0500
13-01-84(F)	0.0740	0.0850	0.2250	..2510	0.669.	104.5000	452.0000	0.6990	39.1600	6.5570	15.7050	45.1770	33.5180	13.2020	86.6950
27-01-84(F)	0.0220	0.0830	0.2840	0.2990	0.6900	101.5000	445.0000	0.6910	44.6560	7.1880	12.3180	41.1590	42.3230	12.5360	84.4920
MEAN	0.0575	0.0645	0.2725	0.2942	0.6890	101.4600	393.1000	0.6890	52.8078	8.3386	9.2516	39.5986	42.7091	17.6902	82.3077
STD. DEV	0.0280	0.0220	0.0342	0.0350	0.0609	1.4314	87.5250	0.0606	12.1467	2.5745	3.0576	4.3314	3.3325	2.7017	2.7014
MINIMUM	0.0040	0.0330	0.2160	0.2510	0.5850	99.7000	298.0000	0.5850	32.0910	6.0660	4.6800	34.5860	37.5180	13.3020	78.9030
MAXIMUM	0.0870	0.0850	0.3290	0.3620	0.7980	104.5000	525.0000	0.7860	67.4160	14.0090	15.7050	46.8960	48.2260	21.0950	86.6950

Figure 4A

METHANE SURVEY IN 14 NORTH OF NO.26 COLLIERY

(METHANE CONCENTRATION VS. DISTANCE FROM THE FACE IN THE RETURN GATE)

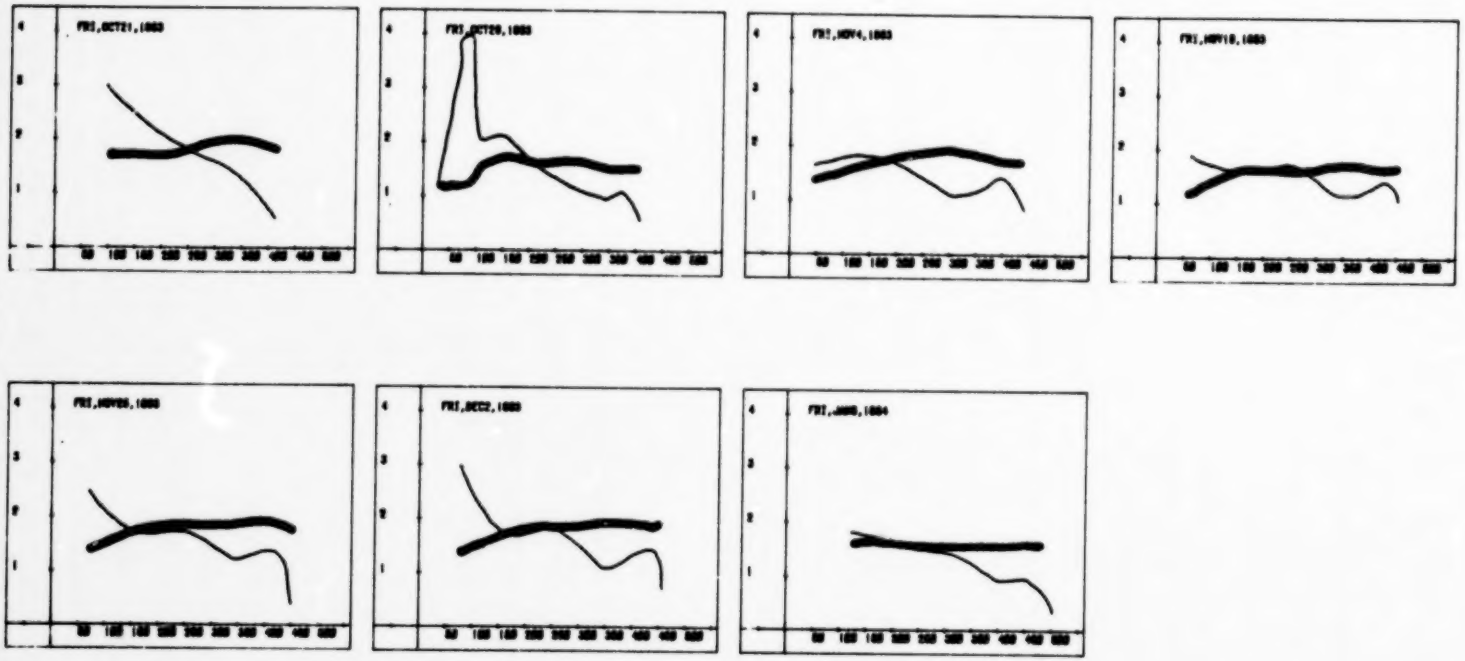


G.A.B. CONCENTRATION ——— GOB CONCENTRATION ———

Figure 4B

METHANE SURVEY IN 14 NORTH OF NO.26 COLLIERY

(METHANE CONCENTRATION VS. DISTANCE FROM THE FACE IN THE RETURN GATE)



G.A.B. CONCENTRATION ——————— GOB CONCENTRATION ———————

of the wallface because of the irregularity of related areas of cross-sections at the points of measurement. It is the author's view that the calculated figure of methane make for this part of the district could be slightly understated because of the inevitable leaks of some air behind the face supports directly into the return. Methane from seams in adjacent strata above and below the seam being worked from ahead of the coalface is assumed to enter the return airway. However, if the sources are close to the seam being worked, some of the methane released will enter the face ventilation. A well designed and maintained methane drainage system by cross-measure boreholes in the return gate can capture a substantial portion of the methane released from seams in adjacent strata behind the coalface except from the sources that are within the caved zone (Figure 2). Methane from sources in the caved zone and also the portion that is not captured by the methane drainage enters the gob and the return gate. Therefore the gradual increase in the methane content of air in the return gate is in conformity with this process (Table 5, Figures 4a and 4b). In contrast to this, methane concentrations in the gob appear to be highest near the wallface declining gradually towards the outbye end of the return gate and falling below the concentrations in the return gate. The phenomenon could be explained by the following factors:

1. Pressure difference between the intake and the return gates is maximum at the outbye end of the gates. It declines gradually towards the wallface (Figure 5). This results in not only maximum fresh air leakage through the gob but also influences the flow paths of methane in the caved and cracked strata towards the return gate. In addition the methane emission at the outbye end where the strata had time to degas, is much less than from the freshly fractured strata closer to the wallface.
2. In addition to the lower pressure in the return gate, the methane drainage holes are under suction, therefore the direction of methane flow in the cracked strata is towards the return gate and methane drainage holes.
3. Methane concentration in the gob close to the wallface is greater because the strata above and below is freshly cracked and caved and the methane released is just finding its way to the mine openings.

Table 5 - Methane survey in 14 North district: methane concentrations in the general air body of the return gate and the gob

Date and Day	Distance from wallface (m)	%Methane in the General Air Body	%Methane in the Gob
Oct. 17/83	366	1.0	0.3
Monday	256	1.0	0.8
	165	1.0	1.0
	73	0.9	1.0
Oct. 21/83	384	1.8	0.5
Friday	274	1.9	1.6
	183	1.7	2.1
	91	1.7	3.0
Oct. 24/83	390	1.0	0.3
Monday	280	1.0	0.8
	189	1.0	1.0
	98	1.0	1.1
	6	0.7	0.7
Oct. 28/83	405	1.5	0.5
Friday	387	1.5	1.1
	341	1.5	0.9
	296	1.6	1.1
	204	1.6	1.6
	158	1.7	2.1
	113	1.5	2.0
	67	1.2	4.8
	21	1.2	1.1
Oct. 31/83	407	1.1	0.3
Monday	389	1.2	1.0
	297	1.2	0.8
	206	1.1	1.1
	114	1.0	1.2
	23	0.8	0.8

Table 5 - Continued

Date and Day	Distance from wallface (m)	%Methane in the General Air Body	%Methane in the Gob
Nov. 4/83	416	1.7	0.8
Friday	398	1.7	1.4
	306	1.9	1.1
	215	1.8	1.6
	123	1.6	1.8
	32	1.3	1.6
Nov. 7/83	418	1.1	0.6
Monday	399	1.1	0.9
	308	1.2	0.9
	216	1.1	1.0
	125	0.9	1.0
	34	0.7	0.8
	07	0.6	0.6
Nov. 14/83	427	1.0	0.4
Monday	408	0.9	0.7
	317	1.0	0.8
	226	1.0	0.9
	134	0.8	0.9
	43	0.7	0.7
Nov. 18/83	434	1.6	0.9
Friday	416	1.6	1.4
	325	1.7	1.2
	233	1.6	1.7
	142	1.6	1.6
	50	1.1	1.9
Nov. 21/83	436	0.9	0.4
Monday	418	0.9	0.8
	326	0.9	0.8
	235	0.9	0.9
	143	0.9	0.9
	52	0.6	0.9

Table 5 - Continued

Date and Day	Distance from wallface (m)	%Methane in the General Air Body	%Methane in the Gob
Nov. 25/83	445	1.7	0.3
Friday	427	1.8	1.3
	335	1.8	1.2
	244	1.8	1.7
	152	1.7	1.7
	61	1.3	2.5
Nov. 28/83	447	0.9	0.7
Monday	428	0.9	0.8
	337	0.9	0.7
	245	0.9	0.9
	154	0.9	0.9
	62	0.7	1.2
Dec. 2/83	454	1.9	0.7
Friday	436	1.8	1.4
	344	1.9	1.1
	253	1.8	1.8
	162	1.7	1.7
	70	1.3	3.1
Jan. 6/83	497	1.5	0.3
Friday	479	1.5	0.9
	387	1.5	0.9
	296	1.6	1.4
	204	1.6	1.6
	113	1.6	1.8
Jan. 9/83	503	0.8	0.2
Monday	485	0.8	0.5
	393	0.8	0.6
	302	0.9	0.8
	210	0.9	0.9
	119	0.8	1.1
	27	0.6	1.9

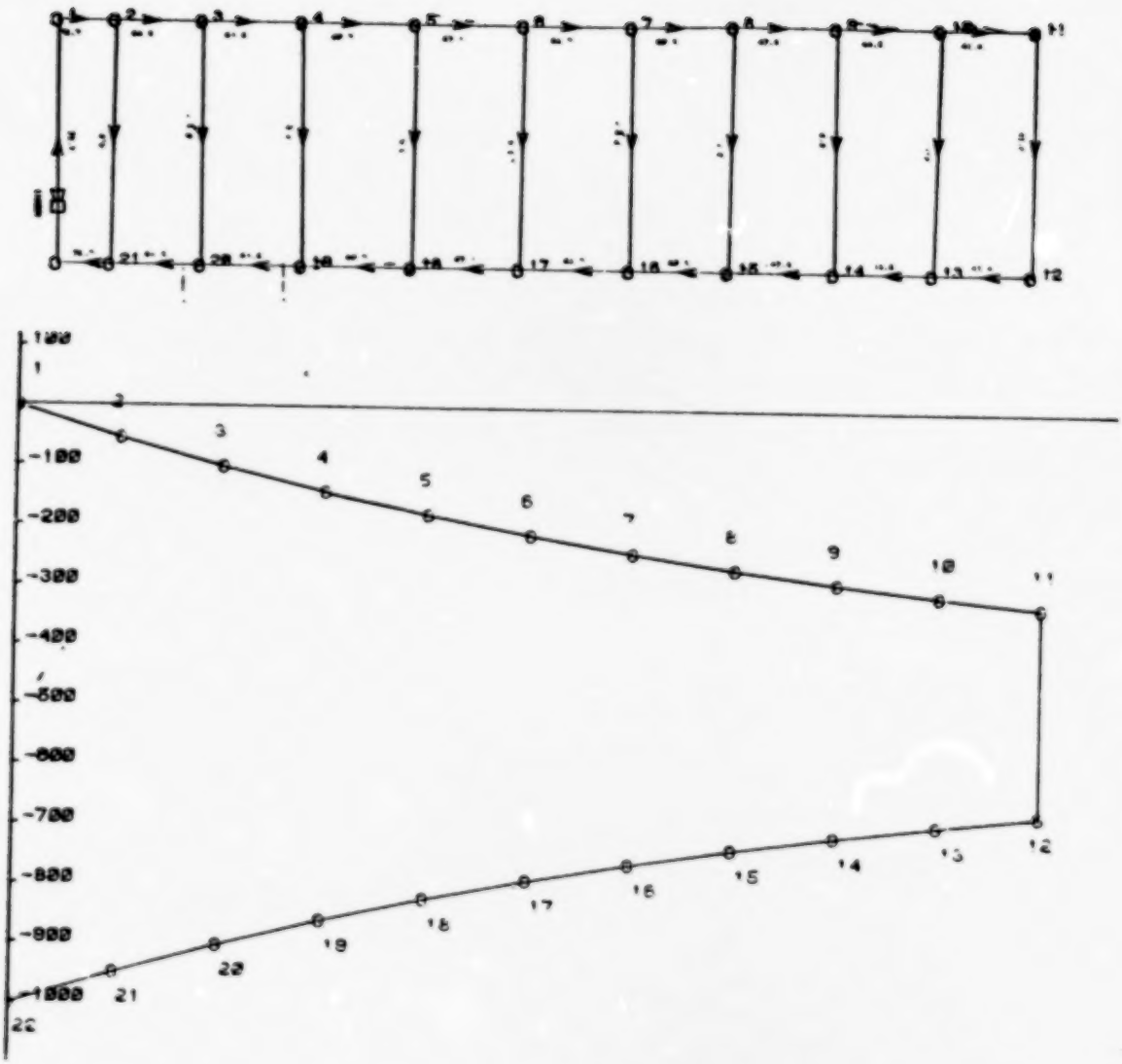


Figure 5 - Typical airflow and pressure diagram for a longwall district in Cape Breton collieries

Also the methane drainage hole closest to the wallface could be 20 - 50 m behind the wallface.

COMPARISON OF AVERAGES FOR MONDAYS AND FRIDAYS

Figure 6 illustrates a typical weekly methane concentration pattern at the outbye end of the return gate of a longwall district. The pattern is determined by the cyclic sequence of working days and work-free weekends. In the example cited (4) production started at 06:00 hours on Monday and ended at 16:00 hours on Friday. Although full production level was achieved within hours of commencement, the methane concentration levels increased only slowly reaching a maximum on the Friday. This sluggish behaviour can be explained by the fact that, while the methane emission on the wallface is related to the distribution and intensity of production with respect to time, the pattern at the outbye end of the return gate is heavily influenced by the emissions from seams in adjacent strata, the movement of which is related to face advance. From the figure it is evident that the methane emission tends towards a saturation level which it would maintain if production were continued at a steady rate. If the output were to increase or decrease, the staturation level would also rise or fall accordingly and the slope of the curve would be steeper or flatter. On the work-free days at the weekend the methane content first of all falls very quickly and then increasingly levels off to a logarithmic function.

Table 6 summarizes various averages for Mondays and Fridays and the percentage changes. As expected the Friday values for methane makes in the intake, wallface and the return are substantially higher than for Mondays. However, the change in the amount of methane captured in the drainage system is minimal. This may be due to the fact that the closest major coal seam in the roof (Hub seam) is about 90 m away and Bouthillier seam in the floor at 70 m may not even be in the relaxed zone. Hub seam could be in zone 2 but more likely in zone 3 (Figure 2) of the relaxed strata where rocks are hardly fissured and will give out methane only very slowly. Total methane make in the district for Fridays is about 30% higher than for Mondays but the coal production is about 9% lower which makes the rate of methane make about 40% higher for Fridays.

The proportions of methane makes in various parts of the district indicate that on Fridays the proportions of methane make on the wallface and

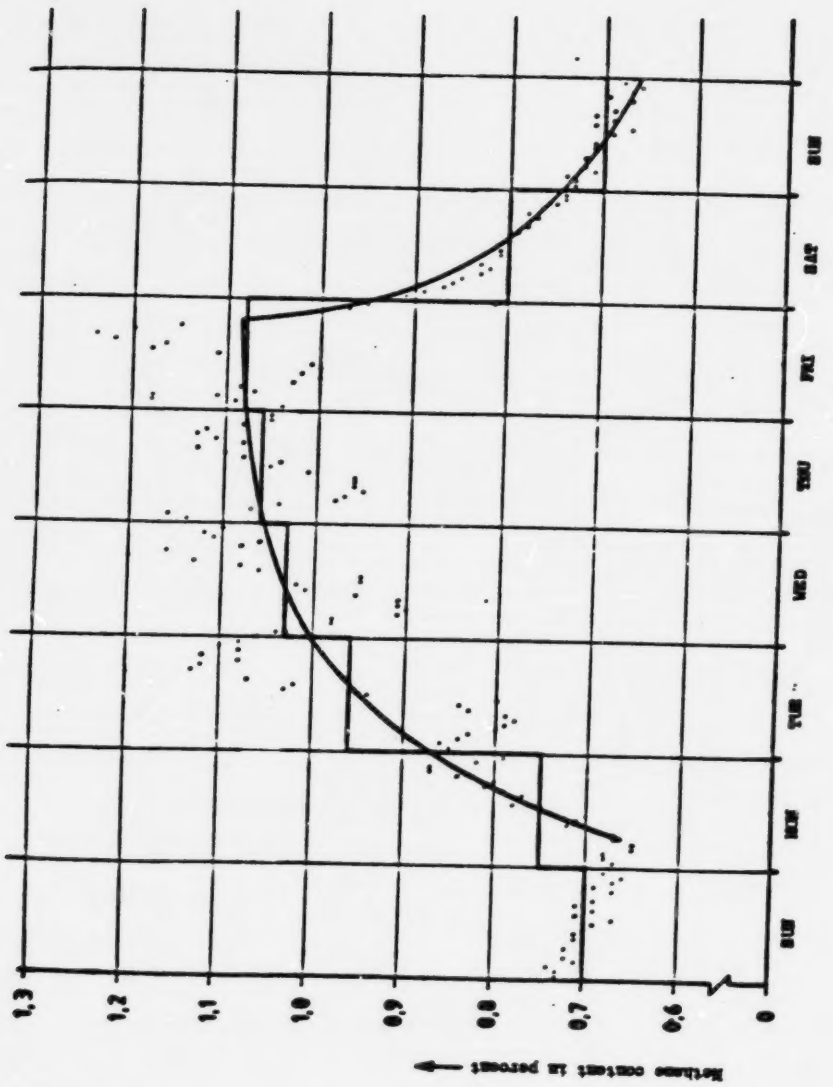


Figure 6 - Typical weekly methane concentration pattern at the outbye end of the return gate of a longwall district (4)

Table 6 - Comparison of averages for Mondays and Fridays

	Average for Mondays	Average for Fridays	Change %	Combined Average
Methane make in the intake (m^3/s)	0.0449	0.0578	+28.7	0.0508
Methane make on the coalface (m^3/s)	0.0346	0.0645	+86.4	0.0482
Methane make in the return (m^3/s)	0.1536	0.2725	+77.4	0.2076
Methane captured in methane drainage (m^3/s)	0.2863	0.2942	+ 2.8	0.2899
Total methane make in the district (m^3/s)	0.5193	0.6890	+32.7	0.5965
Total adjusted for barometric pressure (m^3/s)	0.5203	0.6898	+32.6	0.5973
Coal production/shift of 8 hours (tonnes)	431.5	393.1	- 8.9	414.0
Rate of methane make (m^3/tonne)	37.66	52.81	+40.2	44.54
Proportion of methane make in the intake (%)	8.6	8.3	- 3.5	8.5
Proportion of methane make on the wallface (%)	6.9	9.4	+36.2	8.0
Proportion of methane make in the return (%)	28.6	39.6	+38.5	33.6
Proportion of methane make captured in the drainage (%)	55.9	42.7	-23.6	49.9
Estimated proportion of methane from the seam being worked (%)	15.5	17.7	+14.2	16.5
Estimated proportion of methane from adjacent seams (%)	84.5	82.3	- 2.6	83.5
	Proportions of methane makes in the district excluding methane drainage			
Total methane make in the district excluded methane drainage (m^3/s)	0.2330	0.3948	+69.4	0.3066
Proportion of methane make in the intake (%)	19.3	14.7	-23.8	16.6
Proportion of methane on the wallface (%)	14.8	16.3	+10.1	15.7
Proportion of methane in the return (%)	65.9	69.0	+ 4.7	67.7
Proportion of methane from the seam being worked	34.1	31.0	- 9.1	32.3
Proportion of methane from adjacent seams	65.9	69.0	+ 4.7	67.7

the return are higher and those for the intake and methane drainage are lower. This change in pattern of proportions could substantially be attributed to the fact that while the total methane make for Fridays is about 30% higher, that captured by the drainage system is about the same. This becomes more evident in the proportions calculated excluding drainage.

The proportion of methane make from the seam being worked appears to be about 15 - 20% range and if methane drainage is excluded, it is in the 30 - 35% range.

CONCLUSIONS

While methane surveys of the type discussed in this report are useful to get an idea of the status of ventilation and methane emission pattern in the district, they are not satifactory for making either short, medium or long term forecasts. Continuous reading methanometers and airflow monitors located at strategic locations throughout the district are necessary for a satisfactory quantitative evaluation of methane emissions which can confidently be used in ventilation planning by studying daily, weekly and long term cycles and their relationship to various activities like production, rate of face advance, length of gates, etc. It is hoped that such a system can be installed in a trial longwall district at Lingan.

From both safety and economic points of view, it is essential to have a good understanding and an accurate evalution of methane emission in the district to plan and control activities on highly productive longwall faces.

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